OSSMA Education Series:
Workmanship Standards & Processes

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Garry McGuire,
NASA GSFC, Greenbelt, MD 20771
Code 306, Systems Management Office,
Phone: 301-286-8933; Fax: 301-286-0236
garry.mcguire@gsfc.nasa.gov

Overview

- **The NASA Workmanship Technical Committee has been responsible for NASA's workmanship standards since the mid-1980's, starting with the NHB 5300.4 series of handbooks.**
- **Consists of membership from all ten NASA Centers.**
- **Meets "face to face" semi-annually to discuss:**
  - **Adequacy of current standards.**
  - **Standards under development.**
  - **Implementing "Emerging" technologies (BGA, PEM's, etc.).**
  - **Mandated Changes such as transferring government requirements to voluntary consensus standards (VCS), evaluating lead-free solder alloys, etc.**

Status of Standards

Current NASA Standards as of July, 2003:

- **NASA-STD-8739.1, Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies**
- **NASA-STD-8739.2, Surface Mount Technology (primary emphasis is on automated, or "batch" soldering processes).**
- **NASA-STD-8739.3, Soldered Electrical Connections (primary emphasis is on hand soldering processes).**
- **NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring**
- **NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation**

Status of Standards (cont'd)

Industry Standards Adopted by NASA:

- **ESD Association S20.20-1999, Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices).**
  - **This document replaced NASA-STD-8739.7 in February, 2002 and should be cited on all new procurements.**
  - **ESD control programs previously validated to be in accordance with NASA-STD-8739.7 are fundamentally compliant with S20.20.**
- **IPC 6011, Generic Performance Specification for Printed Boards.**
  - **This is the baseline standard for PWB's. Additional requirements for specific board types (e.g., rigid, flexible) follow in this branch of the IPC documentation tree (see next slide).**

Status of Standards (cont'd)

Industry Standards Adopted by NASA (cont'd):

- **IPC 6012, Qualification and Performance Specification for Rigid Printed Boards.**
  - **Current version (revision A) is to be supplemented by GSFC S312-P-003B, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses.**
  - **A Military/Aerospace "slash sheet" has been developed, but is tied to revision B of 6012. This version is expected to be released by January, 2004. At that time, the GSFC supplement will be replaced by the IPC high reliability slash sheet.**

Status of Standards (cont'd)

Industry Standards Adopted by NASA (cont'd):

- **IPC 6013, Qualification and Performance Specification for Flexible Printed Boards.**
  - **To be used because there is no alternative and it provides a consistent baseline for flexible boards.**
  - **The Workmanship Committee will approach the IPC to develop a high reliability slash sheet for this standard to address areas of concern.**

Near Term Objectives

- **Release Space Addendum to IPC/EIA J-STD-001C, Requirements for Soldered Electrical and Electronic Assemblies.**
  - **Supplements J-STD-001C in areas affected by the thermal cyclic, vacuum, and vibration environments unique to space flight hardware.**
  - **Will replace NASA-STD's-8739.1, .2, & .3.**
  - **Working towards a release date around the end of July, 2003.**
  - **Facilitates a "single process" for NASA's supplier community.**
  - **Enables training to be obtained from any IPC Master Training Site - not just at NASA's Eastern (GSFC) or Western (JPL) region Training Centers as has been historically (and currently) required.**
    - **Higher number of available facilities adds flexibility to scheduling.**
    - **Reduces travel costs associated with getting employees trained.**

Long Term Objectives

- **Release Revision A of IPC A-620, Acceptability of Electronic Wire Harnesses and Cables.**
  - **Will also require an Addendum unique to space similar to the Space Addendum to J-STD-001C.**
  - **Will replace NASA-STD-8739.4**
  - **Anticipating release by the end of calendar year 2004.**
- **Identify a replacement for NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation.**
  - **The IPC formed a task group to address fiber. Will probably result in a family of IPC standards regarding fiber optics.**
- **Provide "real world" implementation guidance for programs or suppliers intending to use Ball Grid Array package styles.**
- **Develop hand soldering and rework guidance for surface mount parts (e.g., chip parts down to 0402 sizes, glass bodied parts).**

Workmanship Web Site

www.workmanship.nasa.gov

Links to:

- **Current standards with short history.**
- **Points of contact at each NASA Center.**
- **Training Resources.**
- **Workmanship, process, and/or design problems resulting in flight hardware failures.**
- **On-line inspector's guide.**
- **Recommended methods for common practices such as splicing wires.**

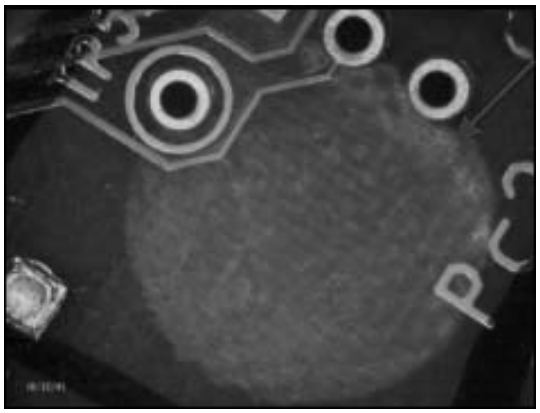
Workmanship Web Site (cont'd)

Workmanship Problems Pictorial Reference

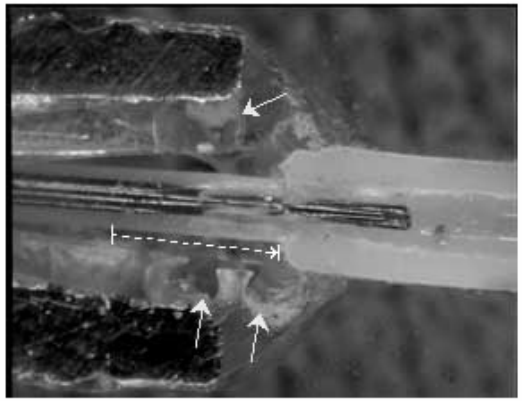
- Over 50 examples of failed hardware that cost real programs real time and money.
- Includes a short narrative of what happened and how the problem could have been avoided.

Workmanship Web Site (cont'd)

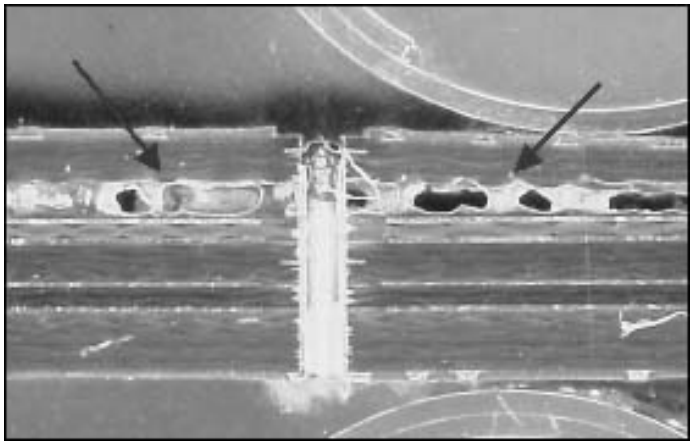
Workmanship Problems Pictorial Reference (cont'd)

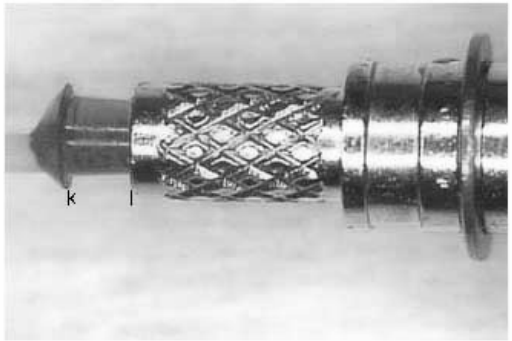


Bare Board
Delamination



Fiber optic
cable buffer
shrinkage





Workmanship

NASA WORKMANSHIP TECHNICAL COMMITTEE

- Home
- Center Contacts
- Workmanship Standards
- Workmanship Problems Pictorial Reference
  - PWAs
  - PWBs
  - Components
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  - Wiring & Cabling
  - Other Technologies
- Inspection Pictorial Reference
- Workmanship Training
- Presentations
- Guidance and Advice
- Feedback
- Links
- Members Only

WORKMANSHIP PROBLEMS PICTORIAL REFERENCE

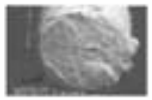
This section is provided to illustrate some of the reasons behind NASA's workmanship and process requirements. Although the images contained in these pages represent unfortunate circumstances, it is our hope to put a positive spin on these in order to prevent their reoccurrence. If you have any questions, please feel free to send them to us.


Printed Wiring Assemblies


Fiber Optics


Printed Wiring Boards


Wiring and Cabling


Components

Workmanship

NASA WORKMANSHIP TECHNICAL COMMITTEE

WORKMANSHIP PROBLEMS PICTORIAL REFERENCE

Printed Wiring Assemblies (PWAs)


1. Bubbles in conformal coating under FPGA


2. Chlorine contamination NEW


3. Conformal coating non-wetting NEW

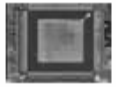

4. Excessive staking NEW


5. Fatigue fracture - no mechanical support

6. Fiber contamination in conformal coating.


7. Improper modification of solder lug causing


8. Improper use of removal tool


9. Insufficient/wrong type of staking material


10. Lack of staking material causing lead breakage


11. Lack of stress relief NEW


12. Possible shorting potential resulting from contamination


13. Solder cup cold solder joint failure


14. Staking compound negating stress relief


15. Staking failure on tantalum capacitor


16. Wavesolder process problem

Workmanship

NASA WORKMANSHIP TECHNICAL COMMITTEE

WORKMANSHIP PROBLEMS PICTORIAL REFERENCE

Printed Wiring Assemblies (PWAs)

Lack of Stress Relief

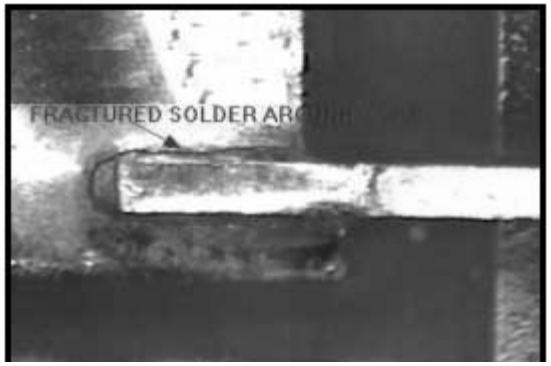
This device failed after environmental testing as a result of not having any stress relief on the leads. Remounting of the part incorporating the proper stress relief was required.

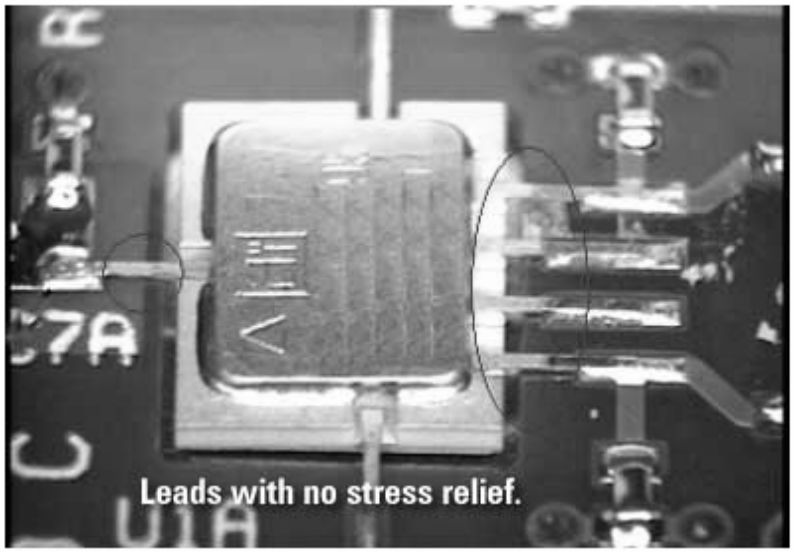
Reference :

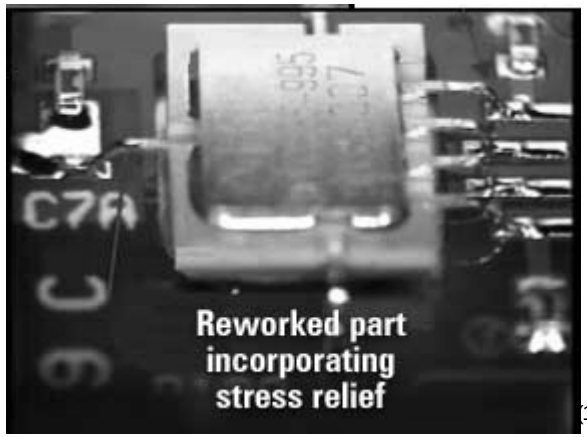
NASA-STD-8739.3,

4.3. Reliable Soldered Connections

2. The following requirements and design objectives should be used to ensure the reliable soldered connections required by NASA:
a. Stress relief should be inherent in the design to avoid detrimental thermal and mechanical stresses on the solder connections.



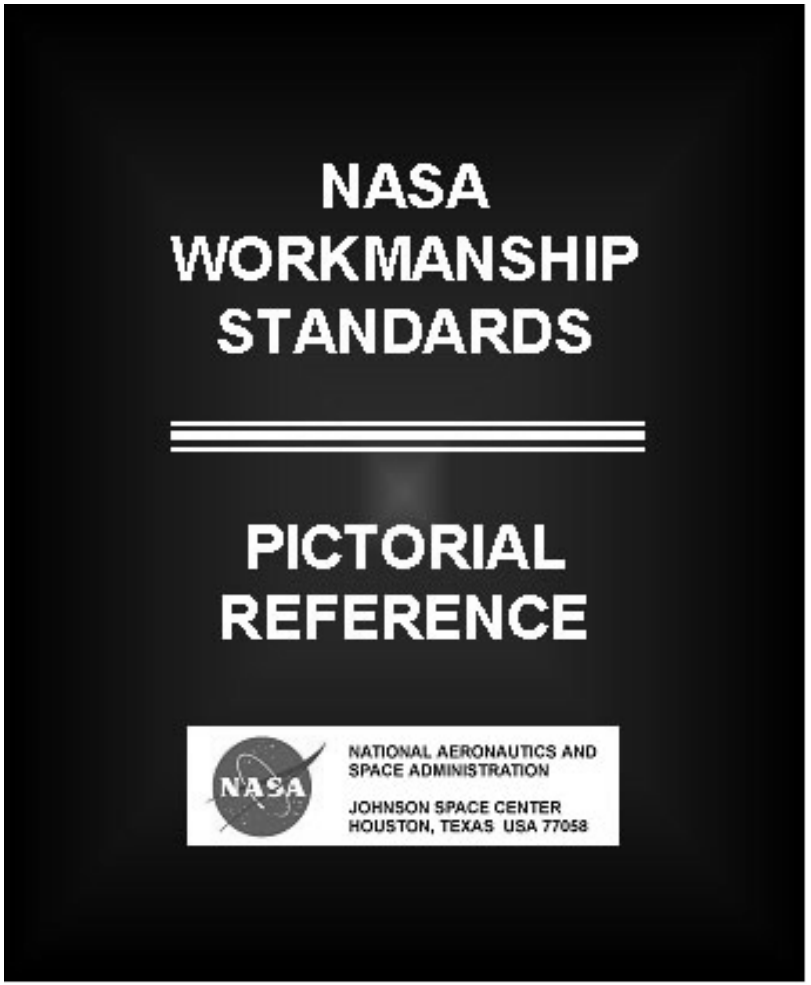




Workmanship Web Site (cont'd)

Workmanship Standards Pictorial Reference*

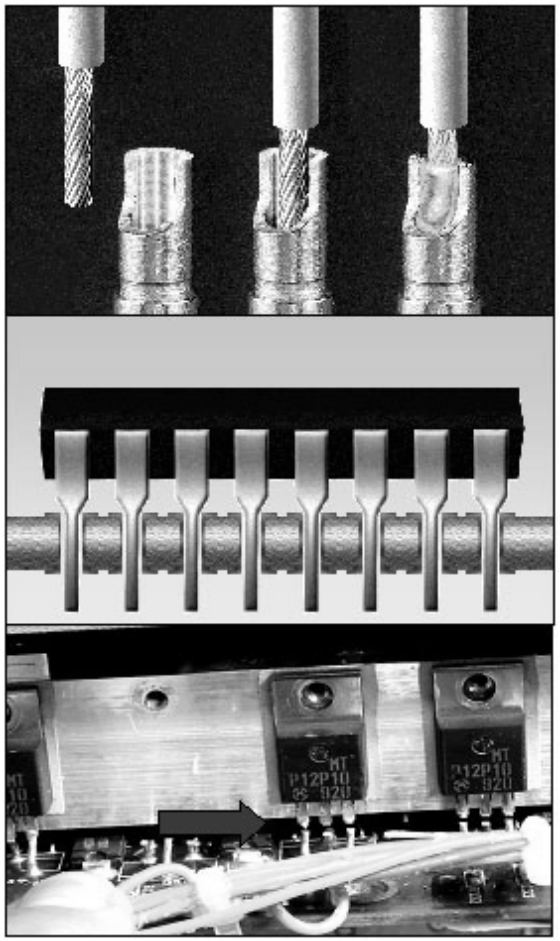
* Created and maintained by JSC's office of Safety, Reliability & Quality Assurance



Workmanship Web Site (cont'd)

Workmanship Standards Pictorial Reference (cont'd)

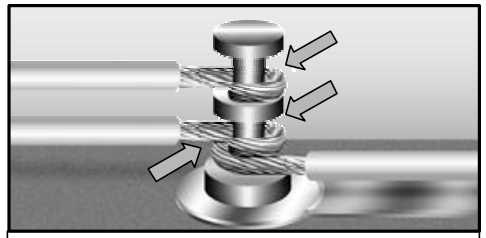
- **To present acceptance and rejection criteria for electronic hardware intended for high-reliability space applications.**
- **To provide a more uniform interpretation of the standards by Quality Control and Manufacturing personnel.**



Workmanship Web Site (cont'd)

Workmanship Standards Pictorial Reference (cont'd)

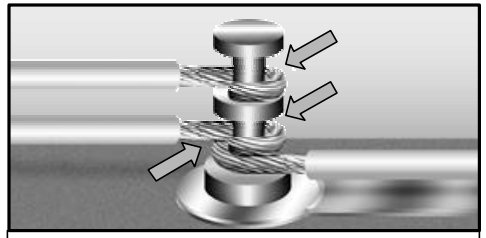
A VCS version is in development that aligns applicable NASA-STD-8739.* workmanship references to IPC/EIA J-STD-001C references.



GENERAL REQUIREMENTS
WRAP ORIENTATION

Conductors may be wrapped clockwise (CW) or counterclockwise (CCW) to the terminal, but the curvature of dress shall be such that the wrap will tighten against the terminal if the conductor is pulled.

NASA-STD-8739.3 [9.1.8]



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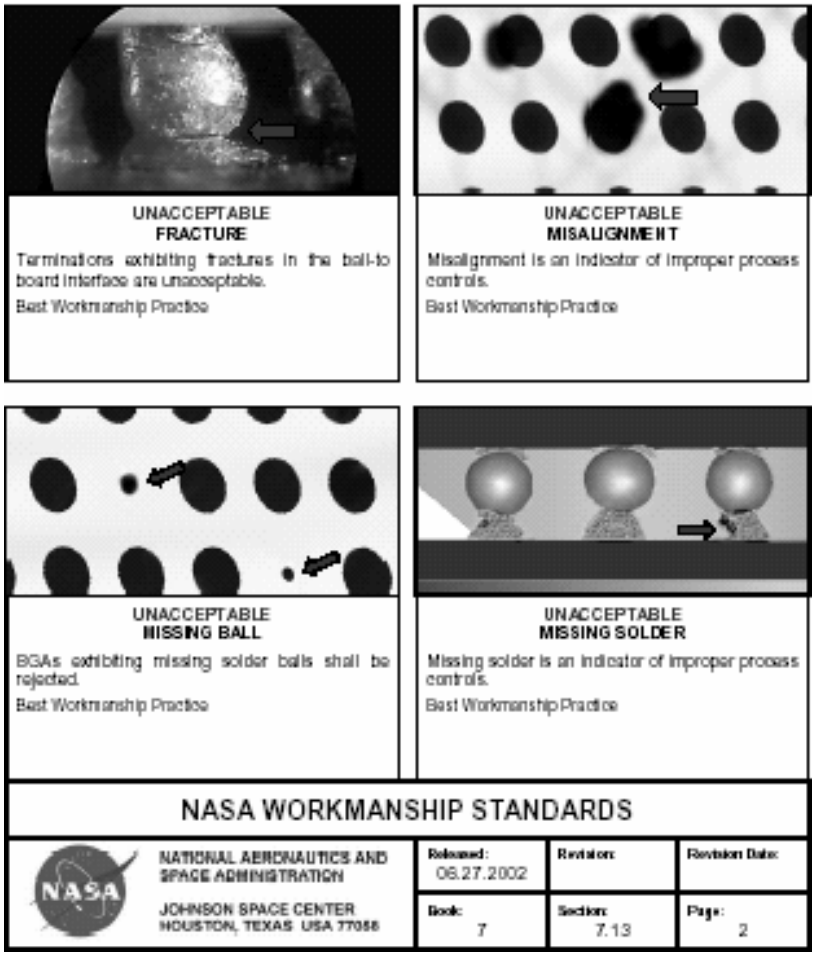
ANSI / IPC J-STD-001C [6.3.2.1], [11.1.14]

Workmanship Web Site (cont'd)

Workmanship Standards Pictorial Reference (cont'd)

- Additional sections dealing with new or evolving component technologies, termination processes, and accepted repair practices are being incorporated continuously.



Services We Provide

Although the workmanship task is an Agency-wide effort, our experience with manufacturing processes and acceptance requirements, within both NASA and the industry, can benefit GSFC. When requested (and funded), we can provide:

- **Evaluation of unique processes.**
- **Supplier Support:**
  - **Process documentation reviews.**
  - **On-site surveys of processes and controls.**
- **ESD:**
  - **Assist projects with ESD Control Plans.**
  - **Evaluate and report on Project specific ESD controls.**
  - **It is not our role to audit ESD controls at GSFC.**

What You Can Do For Us

- **Inform us of non-standard parts, materials, or processes intended to be used by your programs or suppliers.**
- **Keep us informed of problems. Many can be incorporated into our web-based information pool.**
- **Provide pictorial evidence of lessons learned we can post on our web site.**
  - **If imaging capability is not available, we have a digital camera and can respond quickly so we don't impact progress on programs.**

Code 306 Points of Contact

- **Mike Sampson**
  - **(301) 286-3335, Michael.J.Sampson@nasa.gov**
- **Garry McGuire**
  - **(301) 286-8933, garry.mcguire@gsfc.nasa.gov**
- **Bob Humphrey**
  - **(301) 286-0106, rhumphre@pop300.gsfc.nasa.gov**